FIG.1

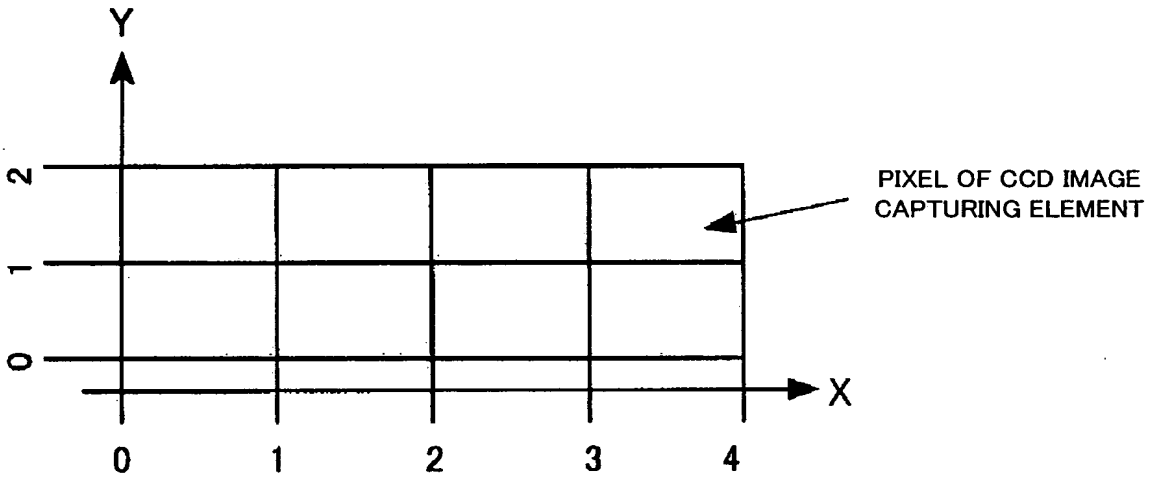


FIG.2

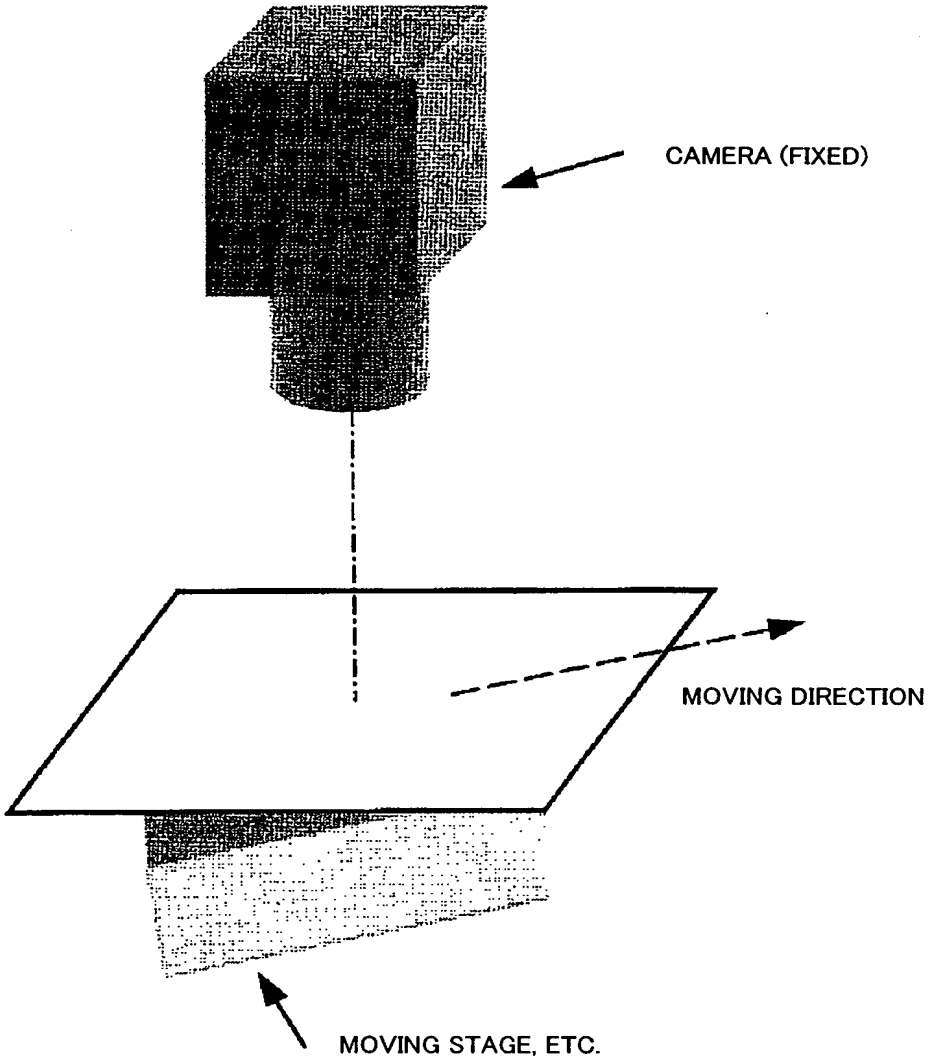


FIG.3

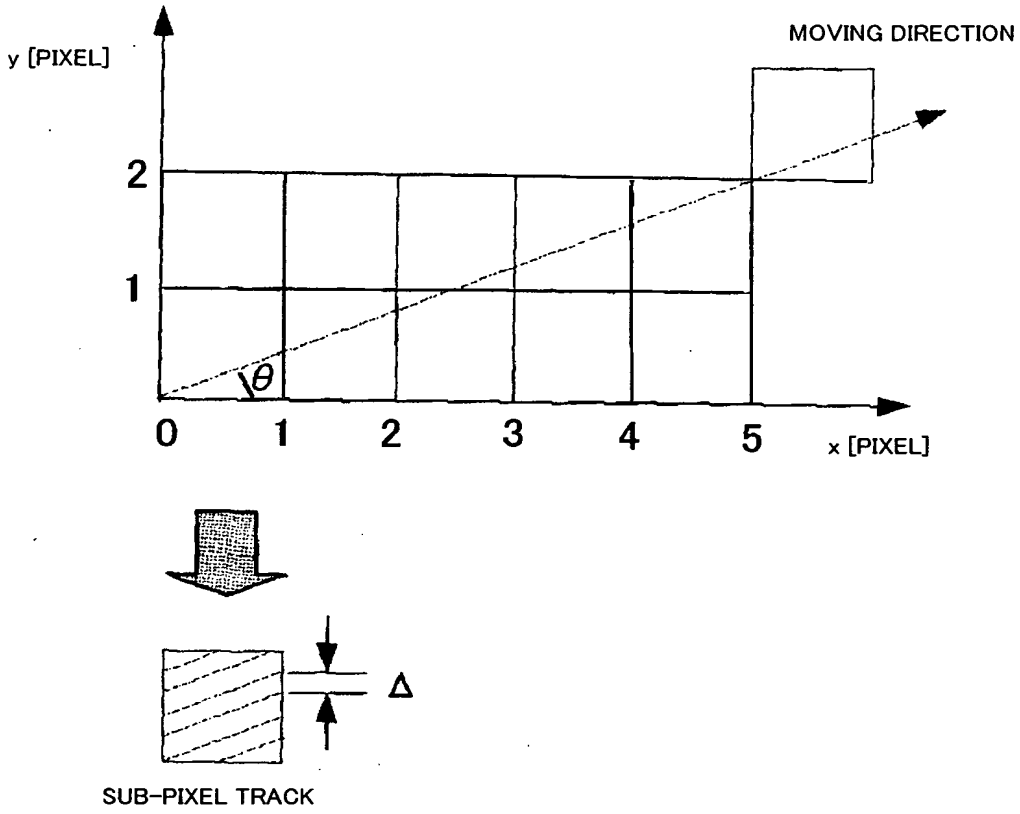
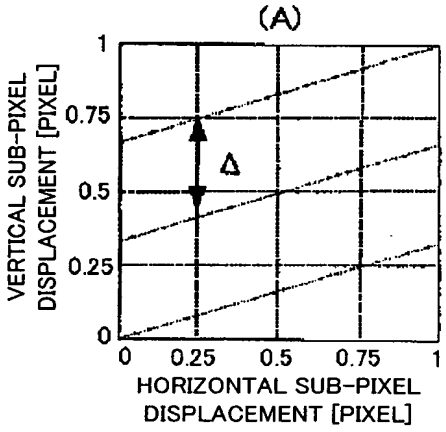


FIG.4

$$\frac{q}{p} = \frac{1}{3}$$

$$\Delta = \frac{1}{3}$$



$$\frac{q}{p} = \frac{2}{3}$$

$$\Delta = \frac{1}{3}$$

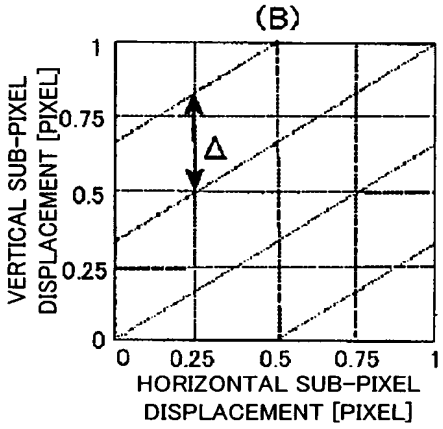


FIG.5

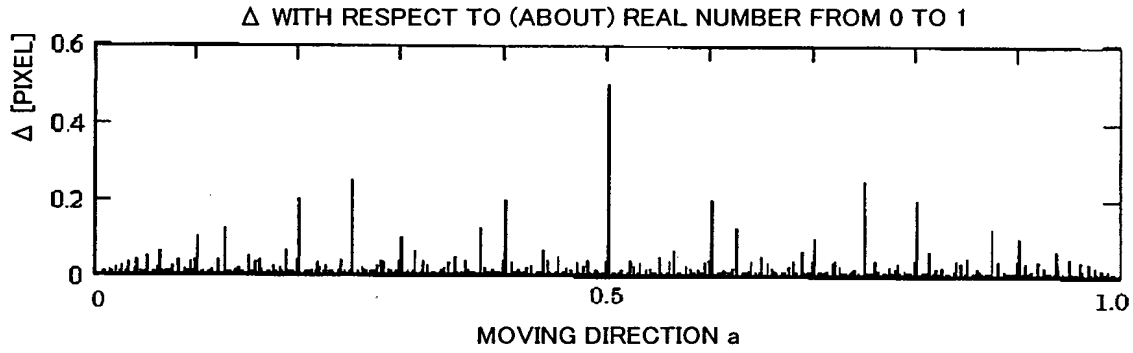

Δ WITH RESPECT TO (ABOUT) REAL NUMBER FROM 0 TO 1
Δ [PIXEL]
0.6
0.4
0.2
0
0
0.5
1.0
MOVING DIRECTION a

FIG.6

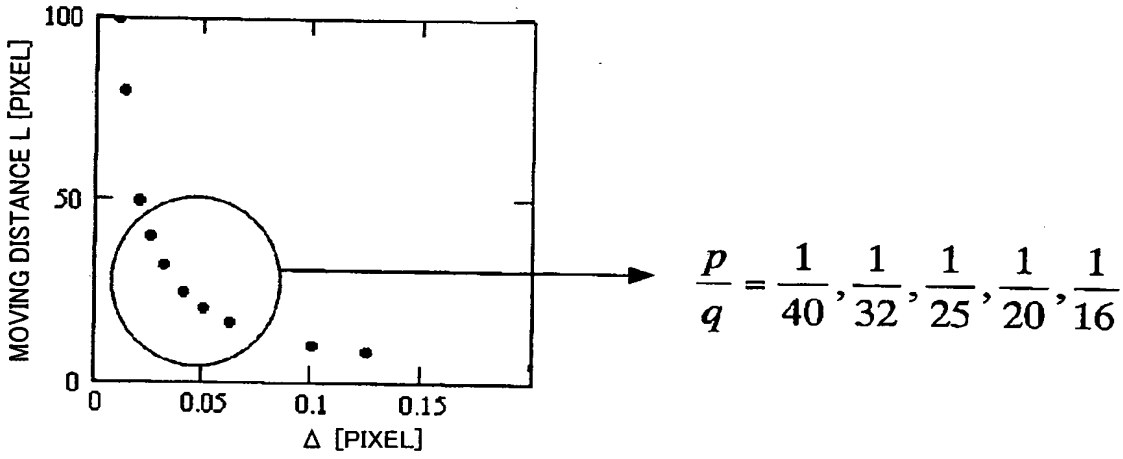

MOVING DISTANCE L [PIXEL]
100
50
0
0
0.05
0.1
0.15
Δ [PIXEL]
$\frac{p}{q} = \frac{1}{40}, \frac{1}{32}, \frac{1}{25}, \frac{1}{20}, \frac{1}{16}$

FIG.7

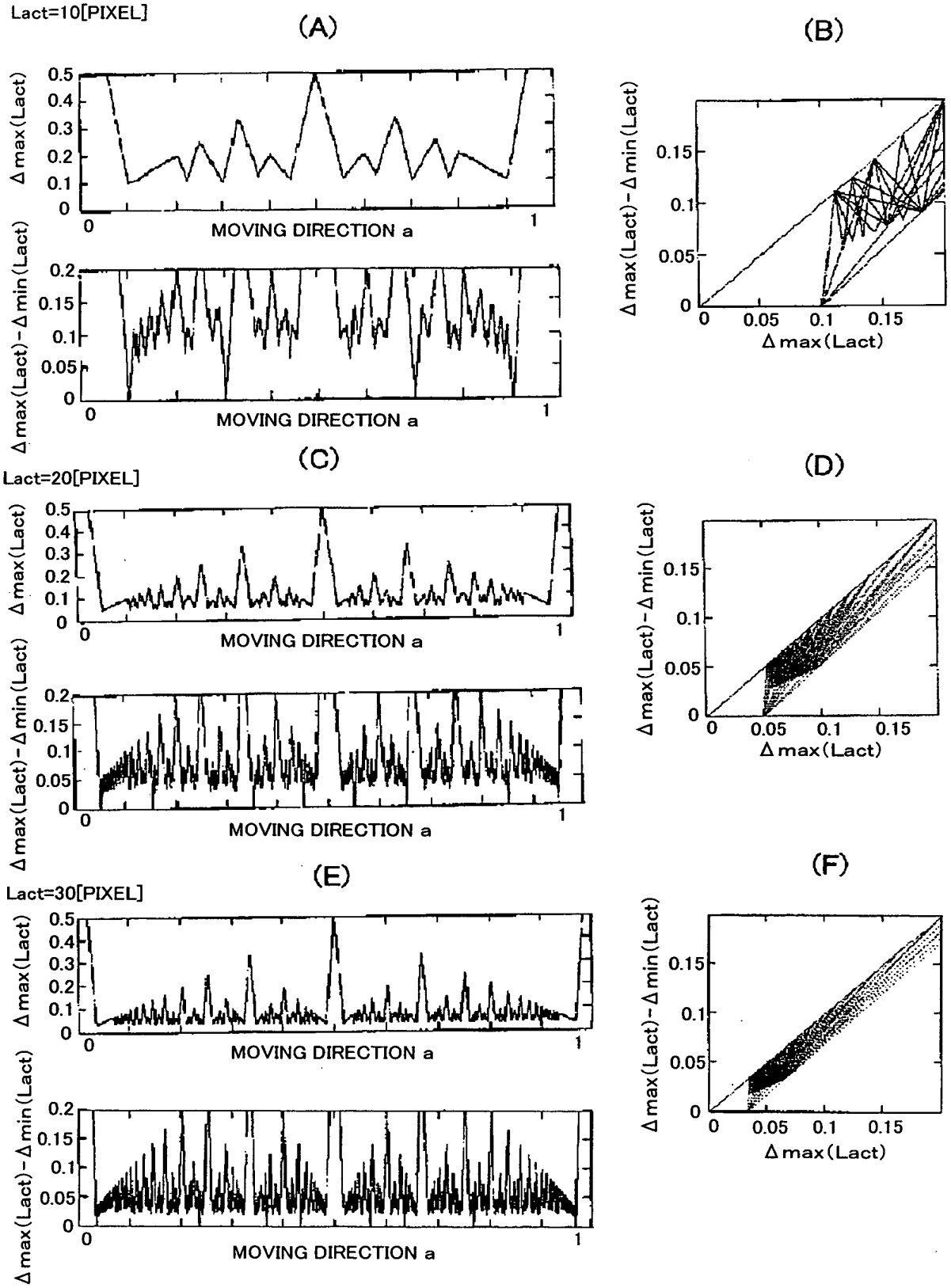

Lact=10[PIXEL]
(A)
(B)
Δmax(Lact)
Δmax(Lact)-Δmin(Lact)
MOVING DIRECTION a
Lact=20[PIXEL]
(C)
(D)
Lact=30[PIXEL]
(E)
(F)

FIG.8

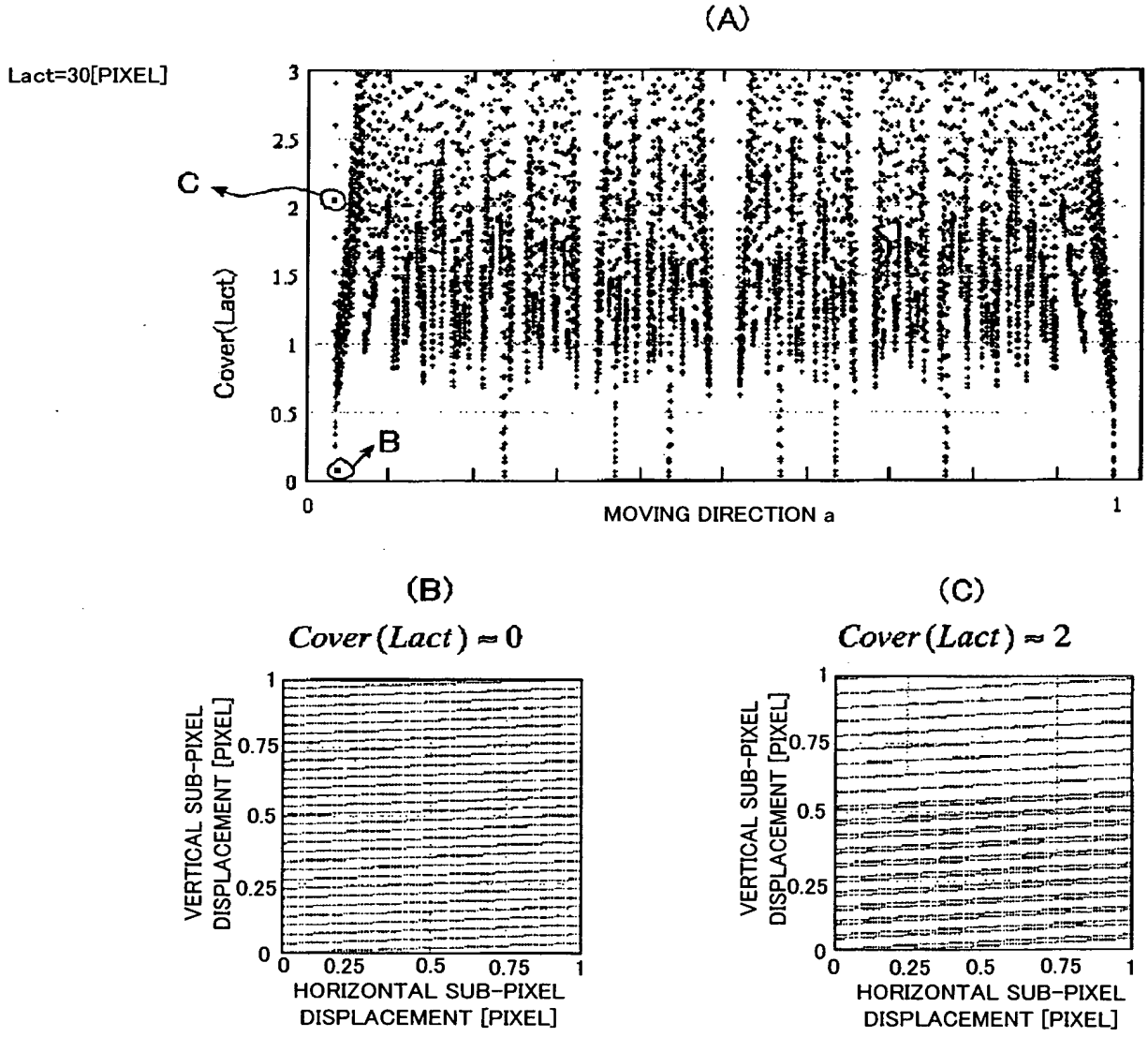

(A)
Lact=30[PIXEL]
Cover(Lact)
C
B
MOVING DIRECTION a
(B)
Cover (Lact) ≈ 0
VERTICAL SUB-PIXEL DISPLACEMENT [PIXEL]
HORIZONTAL SUB-PIXEL DISPLACEMENT [PIXEL]
(C)
Cover (Lact) ≈ 2
VERTICAL SUB-PIXEL DISPLACEMENT [PIXEL]
HORIZONTAL SUB-PIXEL DISPLACEMENT [PIXEL]

FIG.9

$$\text{Delta_max}(p,q,\text{Lact}) := \left|\begin{array}{l} \text{for } n \in 0..\text{Lact}-1 \\ \quad B_n \leftarrow \frac{q}{p}\cdot n - \text{floor}\left(\frac{q}{p}\cdot n\right) \\ C \leftarrow \text{sort}(B) \\ C_{\text{Lact}} \leftarrow 1 \\ \text{for } n \in 0..\text{Lact}-1 \\ \quad dB_n \leftarrow C_{n+1} - C_n \\ dC \leftarrow \text{sort}(dB) \\ dC_{\text{Lact}-1} \end{array}\right.$$

$$\text{Delta_min}(p,q,\text{Lact}) := \left|\begin{array}{l} \text{for } n \in 0..\text{Lact}-1 \\ \quad B_n \leftarrow \frac{q}{p}\cdot n - \text{floor}\left(\frac{q}{p}\cdot n\right) \\ C \leftarrow \text{sort}(B) \\ C_{\text{Lact}} \leftarrow 1 \\ \text{for } n \in 0..\text{Lact}-1 \\ \quad dB_n \leftarrow C_{n+1} - C_n \\ dC \leftarrow \text{sort}(dB) \\ dC_0 \end{array}\right.$$

FIG.10

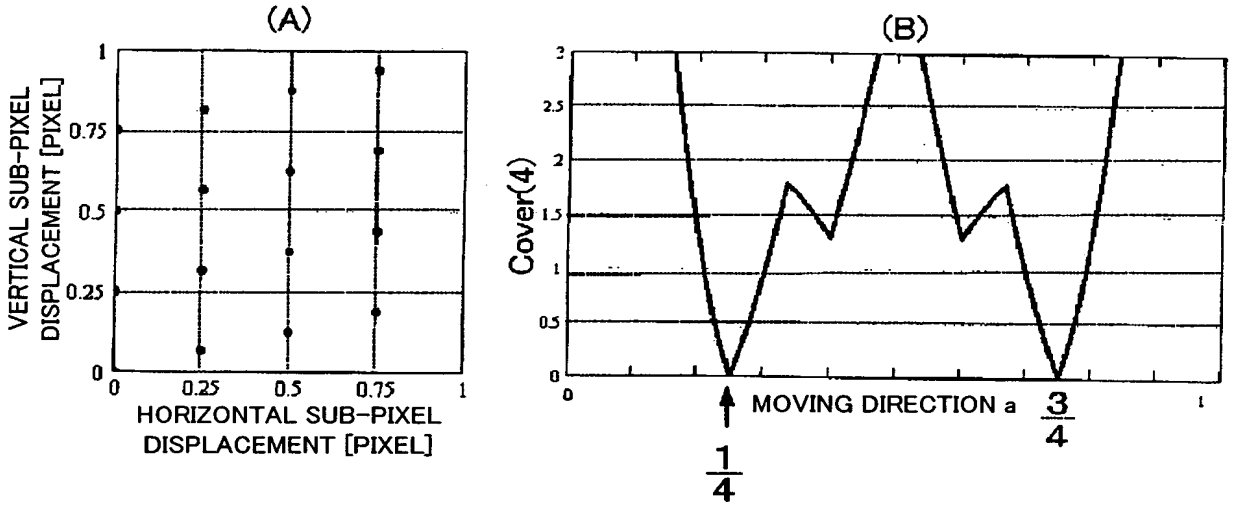

(A)
VERTICAL SUB-PIXEL DISPLACEMENT [PIXEL]
0
0.25
0.5
0.75
1
HORIZONTAL SUB-PIXEL DISPLACEMENT [PIXEL]
(B)
Cover(4)
0
0.5
1
1.5
2
2.5
3
MOVING DIRECTION a
1/4
3/4

FIG.11

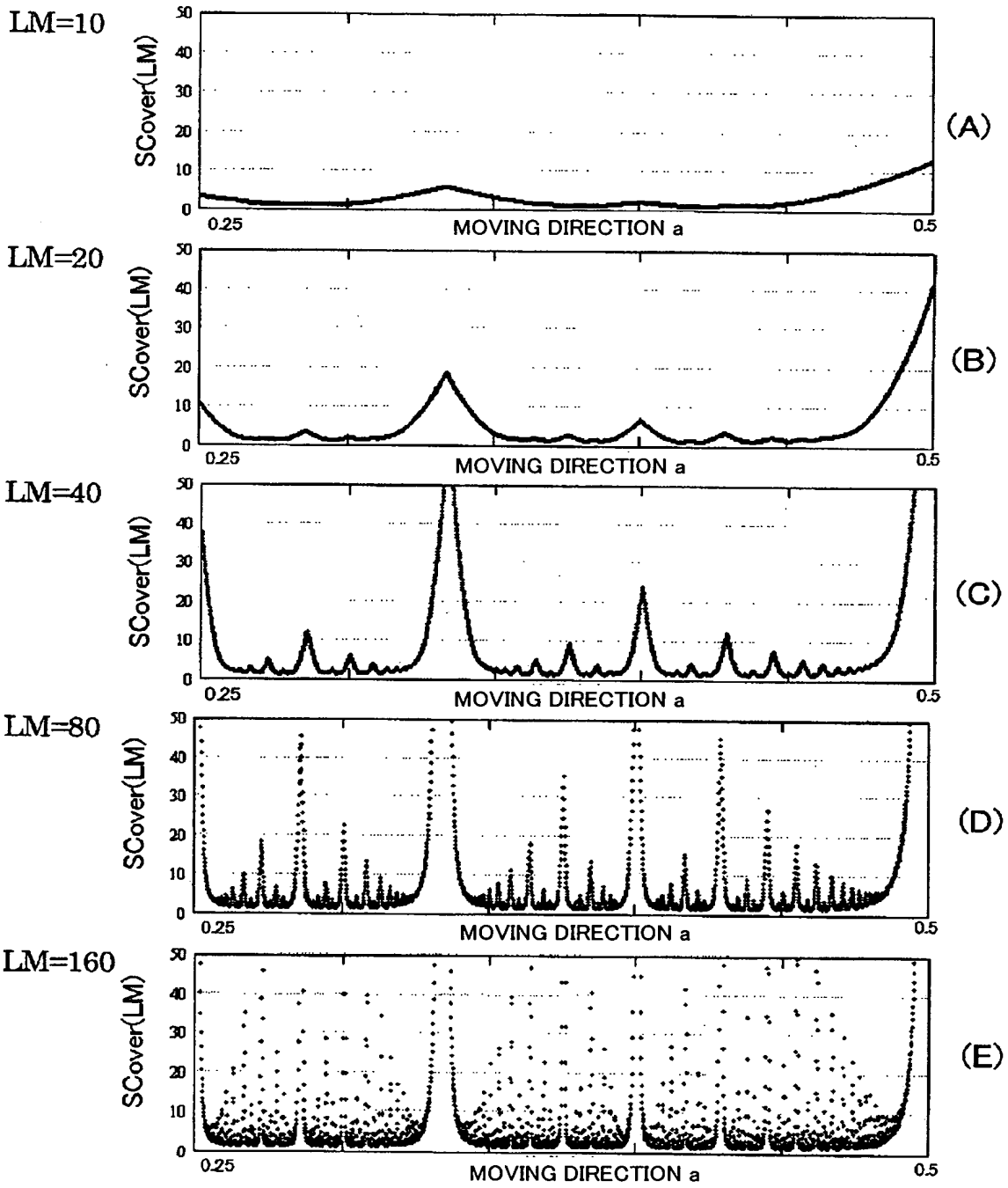

LM=10
SCover(LM)
0
10
20
30
40
50
0.25
MOVING DIRECTION a
0.5
(A)
LM=20
SCover(LM)
MOVING DIRECTION a
(B)
LM=40
SCover(LM)
MOVING DIRECTION a
(C)
LM=80
SCover(LM)
MOVING DIRECTION a
(D)
LM=160
SCover(LM)
MOVING DIRECTION a
(E)

FIG.12

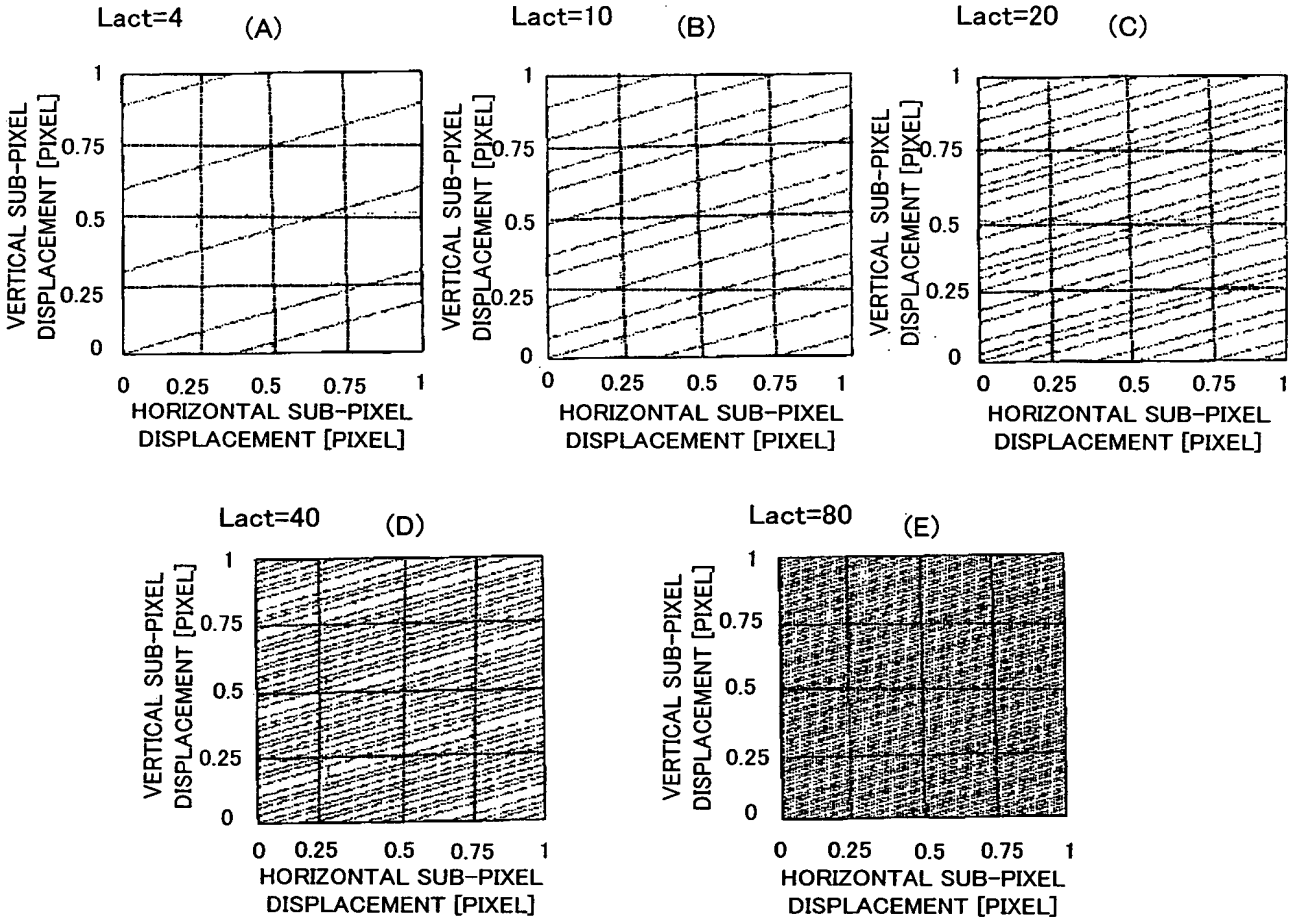

Lact=4
(A)
Lact=10
(B)
Lact=20
(C)
Lact=40
(D)
Lact=80
(E)
VERTICAL SUB-PIXEL DISPLACEMENT [PIXEL]
HORIZONTAL SUB-PIXEL DISPLACEMENT [PIXEL]
0
0.25
0.5
0.75
1

FIG.13

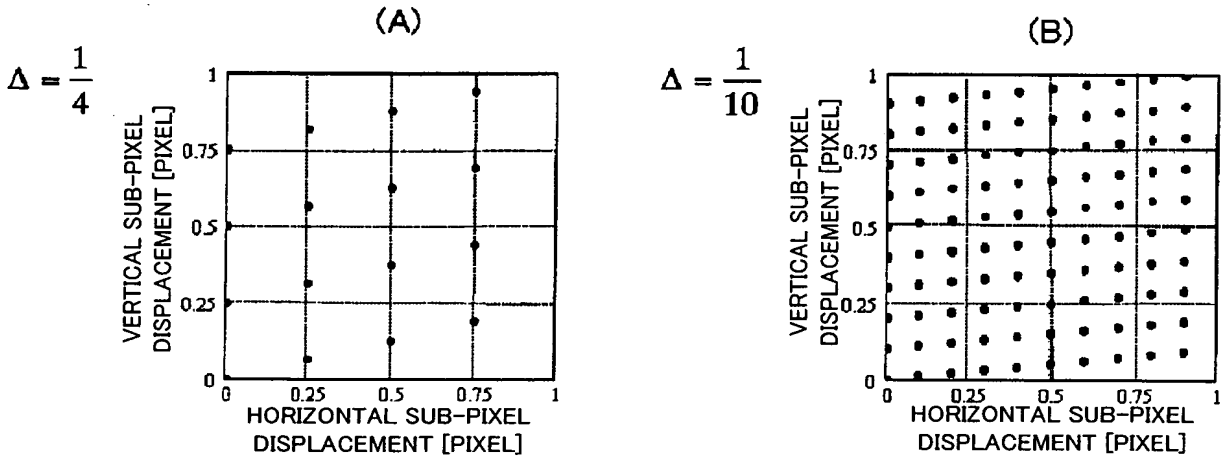

(A)
$\Delta = \frac{1}{4}$
(B)
$\Delta = \frac{1}{10}$
VERTICAL SUB-PIXEL DISPLACEMENT [PIXEL]
HORIZONTAL SUB-PIXEL DISPLACEMENT [PIXEL]
0
0.25
0.5
0.75
1

FIG.14

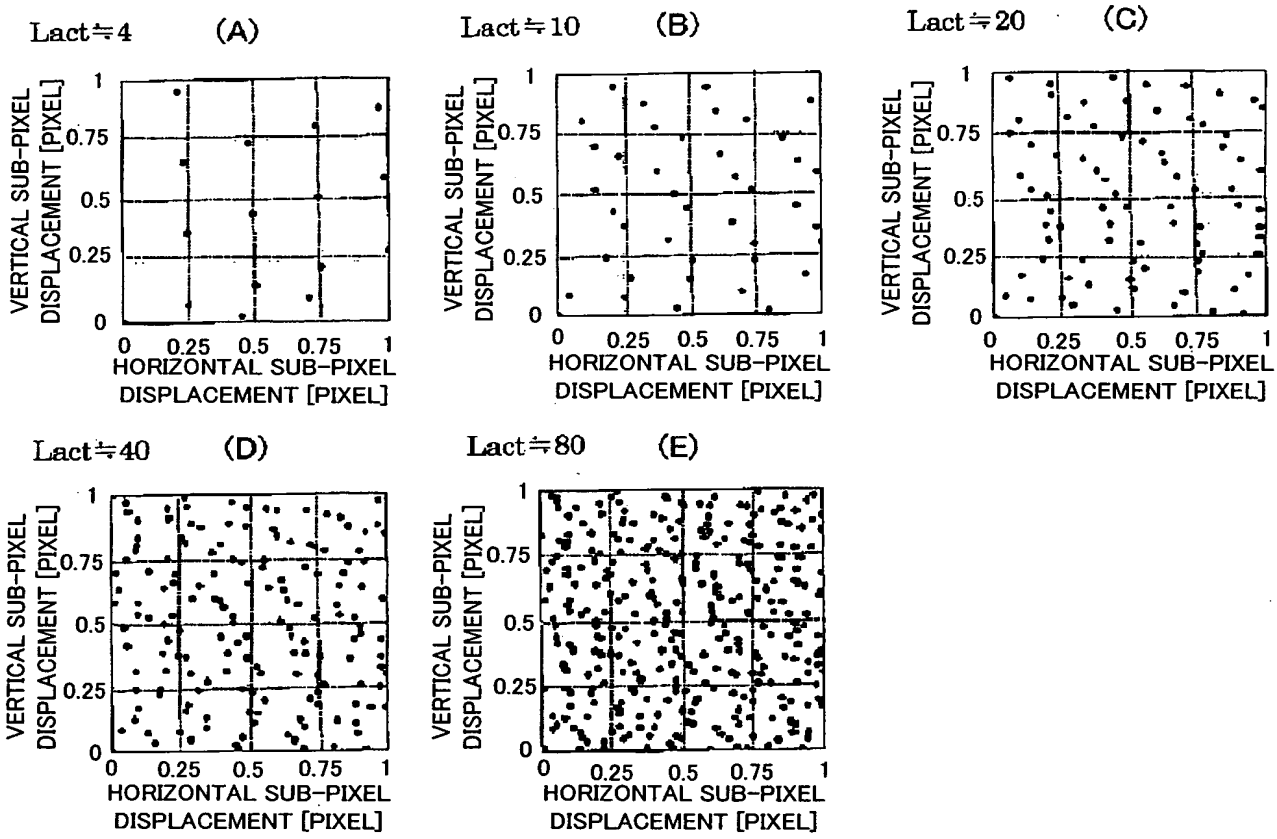
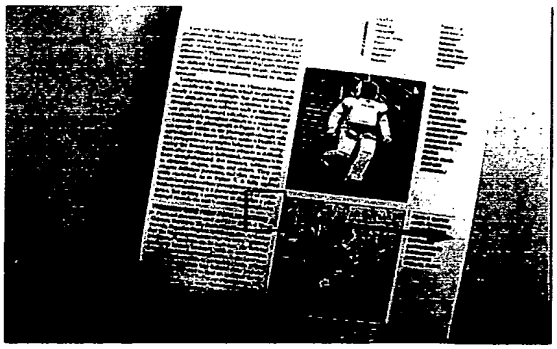

Lact≒4
(A)
Lact≒10
(B)
Lact≒20
(C)
Lact≒40
(D)
Lact≒80
(E)
VERTICAL SUB-PIXEL DISPLACEMENT [PIXEL]
HORIZONTAL SUB-PIXEL DISPLACEMENT [PIXEL]
0
0.25
0.5
0.75
1

FIG.15

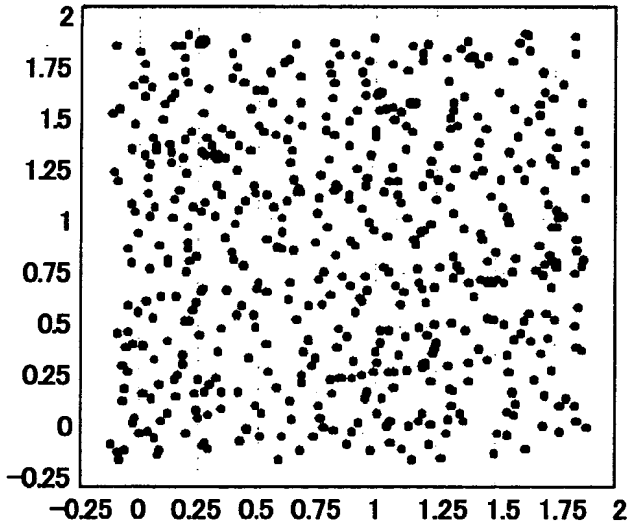
(A)



Lact=107.3, a=14.2/107.3

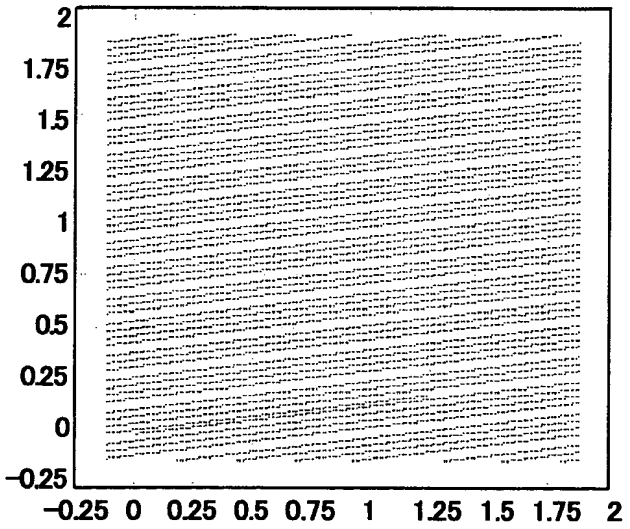
(B)

MEASURED SUB-PIXEL MOTION DISTRIBUTION

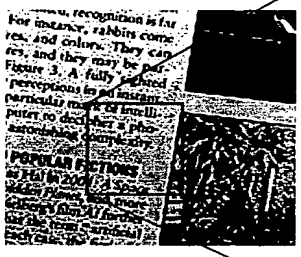


(C)

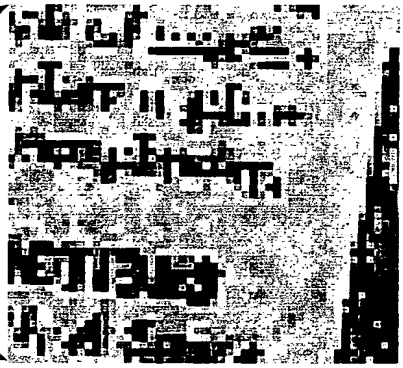
CALCULATED SUB-PIXEL MOTION DISTRIBUTION



(D)

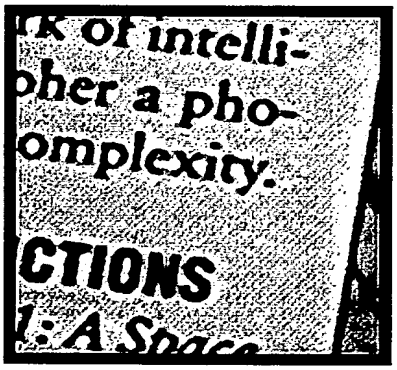


(E)



SIMPLE ENLARGEMENT OF
Kodak DEMOSAICING PROCESS

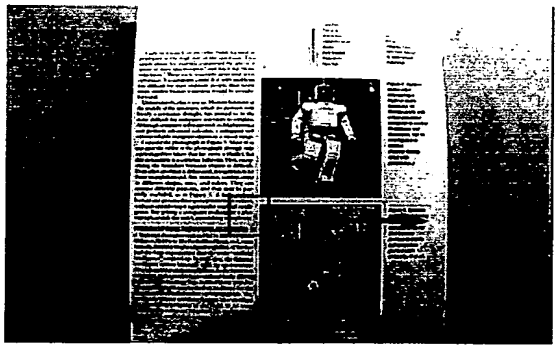
(F)



RESULT OF SUPER-
RESOLUTION PROCESS

FIG.16

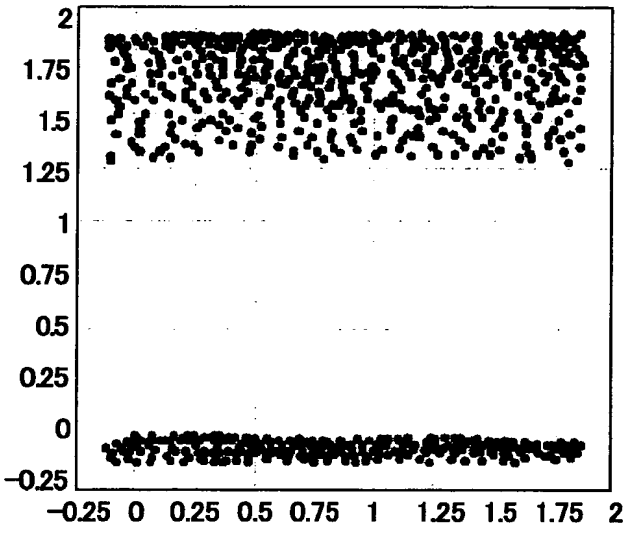
(A)



Lact=54.1, a=-0.7/54.1

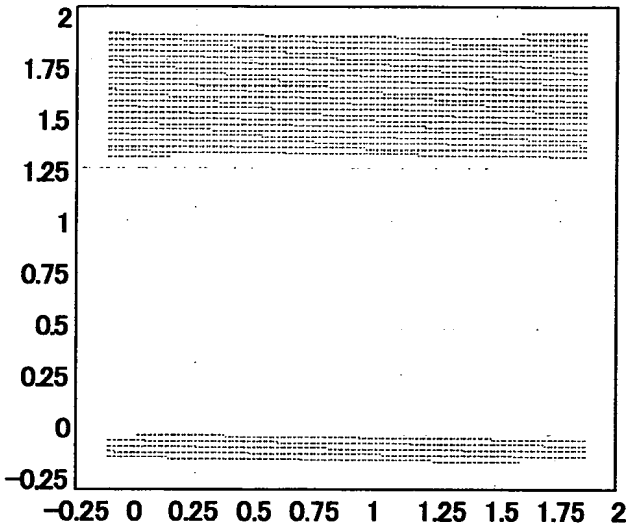
(B)

MEASURED SUB-PIXEL MOTION DISTRIBUTION

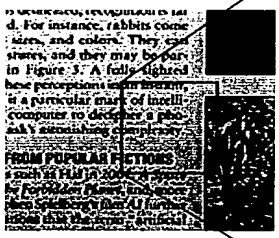


(C)

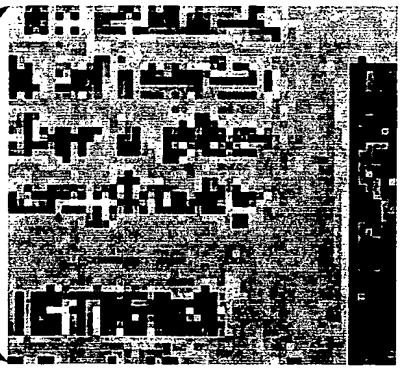
CALCULATED SUB-PIXEL MOTION DISTRIBUTION



(D)

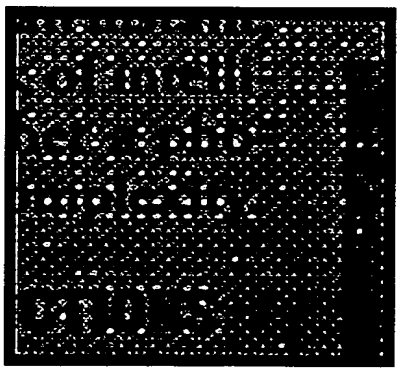


(E)



SIMPLE ENLARGEMENT OF
Kodak DEMOSAICING PROCESS

(F)



RESULT OF SUPER-
RESOLUTION PROCESS

FIG.17

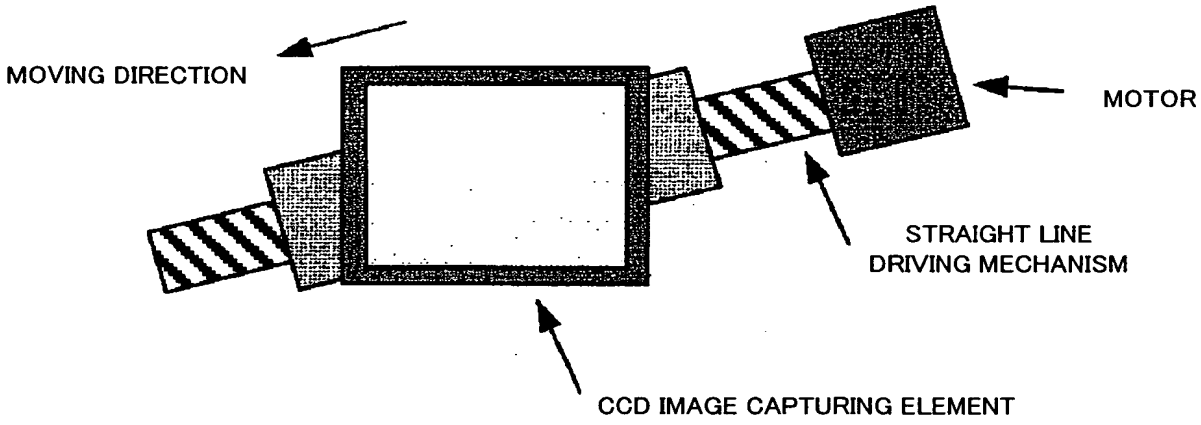

MOVING DIRECTION
MOTOR
STRAIGHT LINE
DRIVING MECHANISM
CCD IMAGE CAPTURING ELEMENT

FIG.18

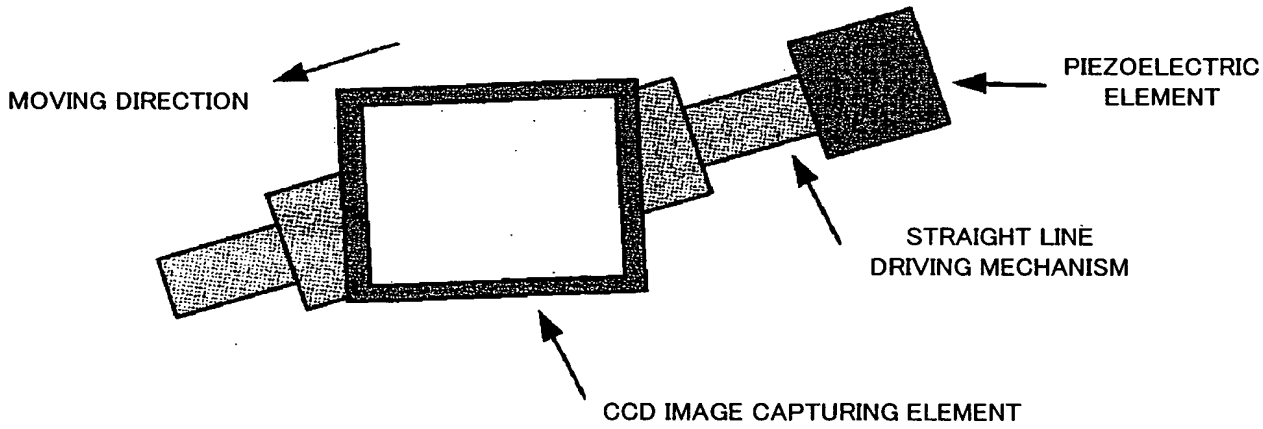

MOVING DIRECTION
PIEZOELECTRIC
ELEMENT
STRAIGHT LINE
DRIVING MECHANISM
CCD IMAGE CAPTURING ELEMENT

FIG.19

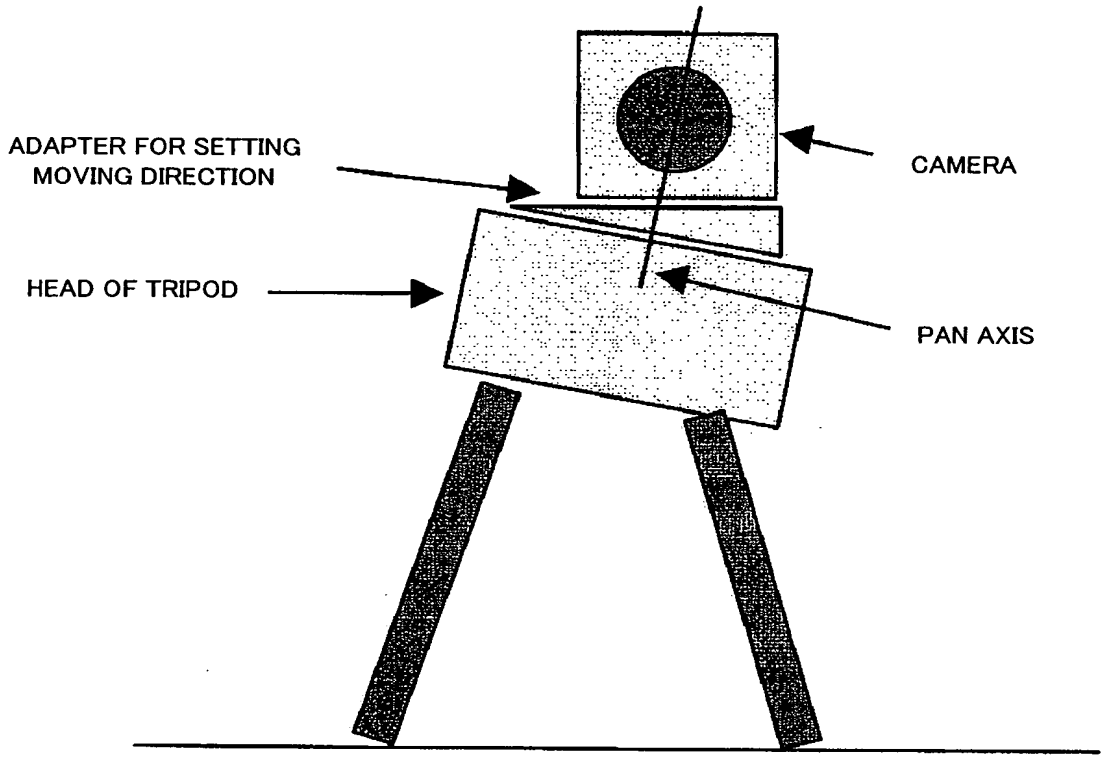

ADAPTER FOR SETTING MOVING DIRECTION
CAMERA
HEAD OF TRIPOD
PAN AXIS

FIG.20

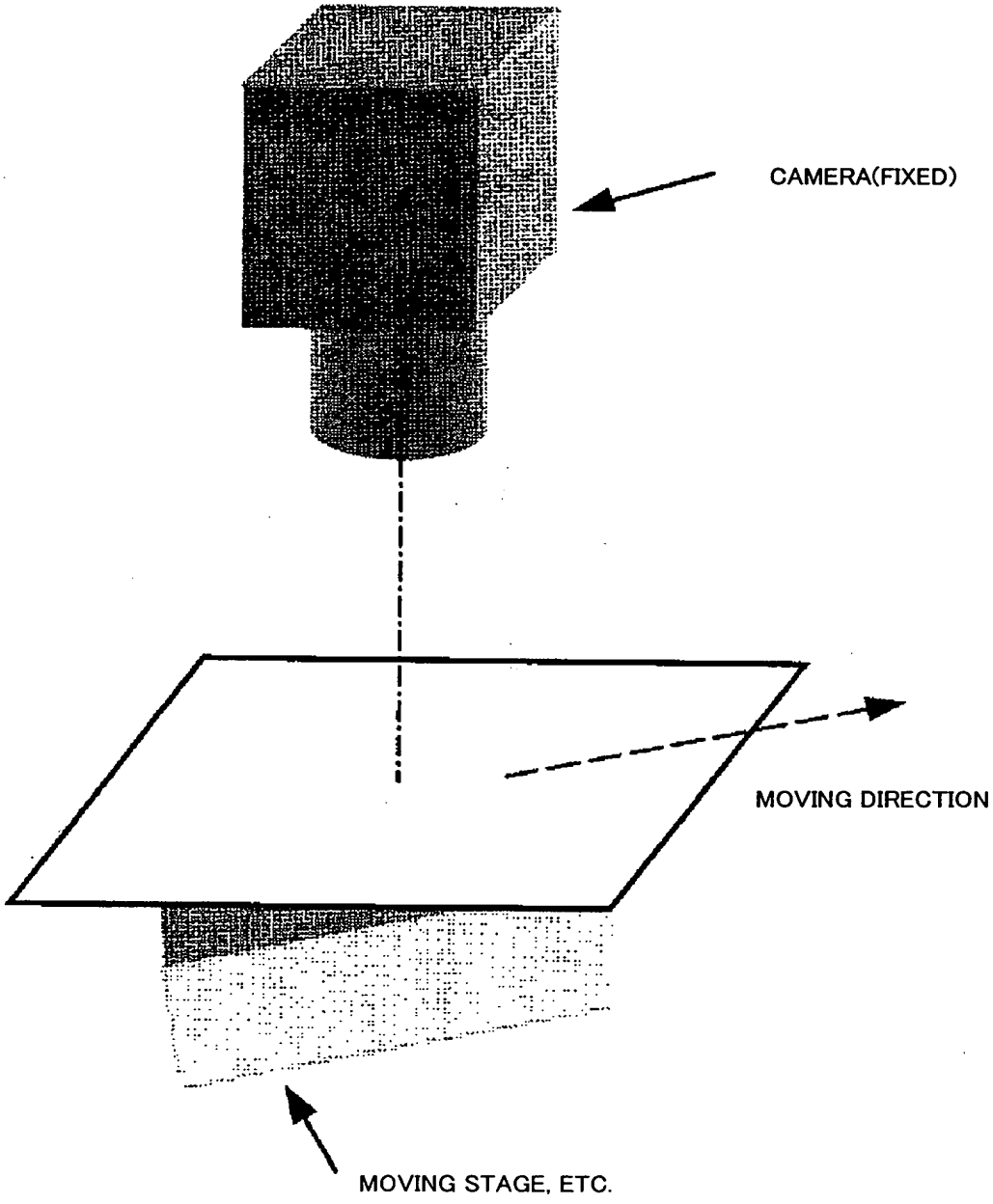
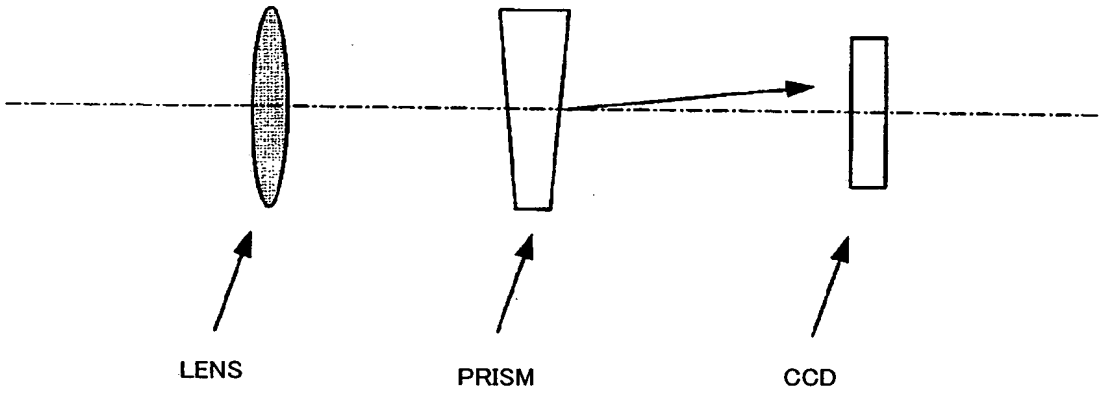



FIG.21